A Plan for Science

SIXPENCE

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INTRODUCTION

This memorandum outlines the manner in which science can assist the people of Britain to solve some of their most urgent industrial and social problems and to raise living standards to the higher level made possible by modern technique and knowledge. This is important not only to the British, but also to the Colonial peoples for whom we have responsibility.

The best use of science is possible only if there is a steadily growing demand for consumer and capital goods at home and abroad, and if, at the same time, conditions of lasting peace and trade stability are established. Without this background, science cannot flourish or be used in the best interests of the people.

A PLAN FOR SCIENCE

INDUSTRIAL RESEARCH

Before the War

Science in Britain under capitalism made great advances and contributed very considerably to world knowledge. We have scientists who are unexcelled.

Nevertheless the formation of monopolies to protect capital and maintain profits by restriction of production has tended to impede the fullest use of our scientific skill and experience. Increasingly, since the beginning of the century, science has been diverted into channels of little benefit to the majority of the people.

The emphasis, before the war, was on selling rather than on improvement or expansion of production. This fact can be illustrated by comparing the £3 million spent annually on all industrial research with £90 million spent on advertising.

Specifically, the failings of the pre-war pattern of scientific work can be summarised as follows:

(1) Neglect of Research. This was particularly true of the basic industries (coal, iron and steel, transport, and textiles). As an example the British Colliery Owners Research Association had an income of £5,000 a year, compared with £80,000 a year for the similar organisation in the electrical industries.

(2) Research Was Unbalanced. Marketing research was pushed at the expense of investigation into productive processes. For example, the coal owners gave more support to the work of the British Coal Utilisation Research Association than to research on methods of coal production. Work producing minor improvements and novelties yielding immediate profits received attention at the expense of more long-term and fundamental research. There was also a tendency to concentrate on production of luxury lines while

neglecting processes to reduce the cost of mass consumption goods.

(3) Wasted Effort. Conditions of commercial secrecy resulted in duplication of work in separate laboratories without exchange of experiences. Co-operative research, more efficient in utilising scientific manpower, was neglected.

(4) **Failure to Apply Results.** Delay in carrying out further research and development held up the application of fundamental discoveries. The results of British work were often applied abroad before they were developed in Britain, as in the case of synthetic dyes, synthetic rubber, certain plastics, and penicillin.

(5) **Suppression of Inventions.** Monopolies have prevented the replacement of old equipment and processes by modern plant; the monopoly abuse clause of the Patent Act was evaded by limited manufacture of a new article; research was done to gain patent control over processes to prevent their use or development; monopolies used their financial power and control of materials to prevent the introduction of competitive products and technical processes. As an example we can quote the agreement between Brunner-Mond (now I.C.I.) and Unilever in 1919 whereby the latter firm undertook to buy all its soda ash requirements from Brunner-Mond, which in turn undertook not to enter the soap market.

Experience of war research shows the value of suitable control, planning and co-ordination. The Government undertook a larger proportion of research than ever before, and took charge of the direction and application of almost all research. Expenditure was unstinted. Striking results were given in the development of radar, jet propulsion and gas turbines, atomic energy, penicillin and D.D.T. The application of science helped to raise labour productivity by about 15 per cent, and by 35 per cent in the munitions industries. Even better results would have been obtained had it not been for the lack of internal democracy and the bureaucratic methods of control in some sectors of State and industrial science.

The Future

The shortage of scientific workers in relation to the enormous programme of research awaiting development makes an extension of government initiative essential. Otherwise, a large part of our research force will be wastefully directed by private industry.

State provision of the funds for industrial research will make such initiative easy. What is wanted is a policy, a general strategic plan to determine the main points of attack, where advances in knowledge can be made in line with the national policy of economic development.

Our total expenditure on industrial research should be raised to £10 or £12 million within 10 years, and eventually to several times that amount. Private industry cannot be expected to provide more than £2 to £3 millions; therefore the gap of £8 to £9 millions must be filled by the public exchequer.

The quality of work by the existing research force can be improved by paying better salaries to research workers, providing better equipment, and employing more technical assistants. But to increase the amount of research by even two or two-and-a-half times its present level in the next ten years requires an extension of trained personnel. As it takes at least three years of university undergraduate training, and a further three years of post-graduate study and work, to produce industrial research workers for the most advanced type of work, the most we can expect from the universities will be a doubling of the pre-war number of trained research workers by 1955.

There must be more democratic co-operative planning of programmes of work, particularly in industry, where the rigid subordination of scientists to administrators or bureaucratically minded directors is a constant source of frustration.

ORGANISATION OF RESEARCH

(a) The Department of Scientific and Industrial Research (D.S.I.R.) must play a greater part in future developments.

It is capable of covering all types of industrial research, forming new laboratories and sub-sections as needed. The D.S.I.R. already has the special advantage of being subject to Parliamentary control which gives it freedom to concern itself with problems of national importance such as: long-term industrial research; efficiency of groups of industries unable to provide their own research resources; properties of materials; heat exchange; general principles of design of factories and plant; research requiring costly equipment.

Before the war expenditure on D.S.I.R. laboratories was about £600,000 per annum. This will have to be increased several times.

(b) **Nationalised Industries.** Research planning and guidance will be simple in nationalised industries, because national interests will replace those of the shareholders, and internal conflicts between different groups of firms in the industry will be ended.

(c) **Research Institutes.** Certain important lines of research lie in an intermediate position between industrial and fundamental academic research. The physics of the solid state and the fundamental aspects of metallurgy are examples. University progress in these subjects requires reinforcement. Special semi-technical institutes, financed by the State and provided with the necessary equipment, are needed.

For work of this type, where economic results are uncertain in any individual case, although certain over the whole field, State finance should be guaranteed for long periods. The administration of the institutes should be in the hands of scientists, drawn both from within and without the institutes.

In the U.S.S.R. large institutes have been established to make the best use of particularly brilliant scientists like Pavlov and Kapitza. Experience has shown that the final results are often great, although it is not possible always to forecast the ultimate gains. Such opportunities must not be missed here.

(d) **Research Associations.** Where research associations already exist, financed by a group of concerns in an industry,

government grants administered through the D.S.I.R. will act both as an encouragement and a means of ensuring co-ordination with the State plan.

The establishment of research associations covering other industries (e.g., civil engineering, mechanical engineering, cinematograph and photographic industries) should be demanded by the government, and the finance obtained by some form of compulsory levy on turnover.

Co-operative research is preferable to private competitive research, which is wasteful. The government should ensure that not less than one-third of the total research effort in any industry is co-operative, that research association results are published, and that all firms in the association derive the benefit of its results.

(e) **Research and Development Contracts.** In highly monopolised industries, such as chemicals, soap, margarine, there is no basis for research associations. In such cases the government could place research and development contracts with the firms, as during the war, and so order and pay for specific pieces of work whose results must be applied to the public benefit. Adequate inspection will be necessary to ensure that work is actually done on the contract. Scientific workers should be encouraged to expose abuses through their trade unions, and should be given protection against victimisation.

(f) **Private Industrial Research.** We must ensure that all private industrial research is in tune with the general development .of national economy. Consequently, government control is essential, along similar lines to the control of private industry evolved in the war. Definite minima of efficiency could be laid down which would compel each firm to improve its work and to undertake the research required.

The course of research pursued by private industry can be influenced by taxation policy. The provisions made in the 1944 Budget for taxation reliefs on research expenditures will help to stimulate industrial research. But taxation relief should be given only if research results are published, and

subject to research programmes and results being submitted to the National Research and Development Council (see page 16). The council should have the right to recommend withdrawal of reliefs if the proposed research is not consistent with national needs.

Fundamental to all questions of the development of industrial science is the need for government action against the abuse by monopolies of their power over scientific research and application. Such abuses are well documented in the U.S.A., but few facts are available here for reasons which are well known.

SCIENCE IN INDUSTRY

Each industry requires a plan for technical equipment and research on which new development can be based. An idea of the work requiring attention is given in the Appendix in a list of essential lines of research and development, which is by no means exhaustive. It is given to stimulate discussion and to provide specialist workers with an overall picture.

Application of Existing Knowledge

Much desirable work cannot be put in hand immediately, because of the lack of scientific manpower. In the immediate future, however, there is an immense amount to be done in the **application** of existing scientific knowledge to industry, to secure rapid improvements in its technical level. Capital must be made available for the wide introduction of techniques already developed in other countries or in a few plants here. The machinery for translating research results into industrial practice, which exists in a highly developed form in the U.S.S.R. and the U.S.A., has been neglected in most British industries and by past governments. With nationalisation of basic industries, and initiative and guidance in respect of other key industries, the government will be able to ensure that research results, ignored in the past, are applied rapidly. Further suggestions to secure the full industrial use of scientific investigation are as follows:

(1) **Patents**—Restore the original intention of the patents

system, to establish new industries in the country. This can be done by reforms such as open licences, under which all who wish may work the patent, the patentee receiving royalties, but no monopoly; by making the grant of a patent more nearly a guarantee of its validity, so that ability to afford expensive litigation ceases to be an important weapon of industrial control; by reducing the period covered by a patent.

(2) **Replacement of Obsolescent Plant**—by its modern counterpart should be stimulated and encouraged by an improved policy of taxation relief, as indicated above.

(3) **Intermediate scale development**—It has been shown, particularly in the U.S.A., that intermediate scale development of a process, following laboratory work, has great advantages. Difficulties likely to be encountered in production are revealed. The industrialist is shown the practicability of the process and encouraged to put it into large-scale use. There is also an enormous financial saving in the course of development from laboratory to industrial-scale practice.

The government should bear these principles in mind when modernisation of the nationalised industries is begun, and in relation to other key industries. A special fund should be available for the Research Associations under the auspices of the D.S.I.R., to ensure that pilot-plant development is undertaken wherever research justifies it.

(4) **Advisory Service**—In industries consisting of many small firms results have not been applied simply because the firms could not themselves support a scientific staff capable of interpreting and developing the results. The scope of Research Associations should be extended to include an advisory service to interpret scientific results in terms of the requirements of any individual firm, and conversely, to bring the problems of the firm in suitable form to the research scientists.

(5) **Survey of past results**—A survey should be made of research results which have not been developed further than the laboratory. Where good results seem likely, they should

be taken to the stage of the pilot-plant or of large-scale industrial application.

(6) **Use of workers' initiative**—The Joint Production Committees, established during the war, were a revelation of the fundamental value of the workers' point of view when considering problems of production, efficiency, new methods, and the introduction of new processes and plant. Unfortunately there was resistance, by the government and employers, to the inclusion of scientific staff representatives on these bodies on the workers' side. Consequently the best results were not obtained from this collective machinery for the discussion of industrial problems. The necessity for taking into account the views of the man or woman at the bench should be axiomatic to scientific workers, since it is the essence of the scientific method that all data on any problem must be collated and examined before the correct conclusion can be drawn. In any case, the workers in industry possess qualifications and advantages which the majority of scientific workers cannot expect to possess. Daily contact with a particular process or sequence of processses, years of experience often accumulated through generations of employment in the same industry, provide the workers with detailed knowledge of tremendous value. The importance of co-operation between the scientific worker, and other workers on Joint Production Committees, or similiar bodies, and consultation with shop stewards cannot be over-emphasised as a vital way of securing the best results in industry.

SCIENCE IN AGRICULTURE

British agriculture needs development and improvement, in its own right as a major industry supporting an important section of the population, and also because the solution of foreign trade problems can be assisted by a large increase in home produced food stuffs.

During the war, agricultural output rose by 70 per cent. One of the main factors in this achievement was the wider application of advanced technique.

If this development is to continue, the knowledge which agricultural science provides must be made available to the farmer in a practical form. We need a big expansion in the Agricultural Advisory Services, so that experts are available to examine and advise on farming problems on the spot, and to refer problems for specialist attention when necessary. The analytical and testing laboratory service should be expanded so that farmers can readily obtain reports on crop and stock quality and methods for their improvement, on soil composition and use, and on pest control. Veterinary services, at present largely engaged in non-farming activities such as race-horse and dog breeding, must be free and available to all farmers.

All these services should become a State responsibility, integrated with the County Agricultural Committees. The functions outlined above would require an eight or tenfold increase in the scale of National Agricultural Services.

Personnel

Present qualifications and training requirements of the Advisory Services are too low. Standards must be progressively raised. Interchange between the Advisory Services and research and educational establishments can be an important factor in raising the level and broadening the outlook of all three.

Research Requirements

The scale of research should be expanded two or three times in the next few years. Some headings for an immediate programme of work are given in the Appendix.

Direction

Most Agricultural research is carried out in institutions largely independent of commercial firms. It has suffered from lack of co-ordination, but it has not been conducted along channels dominated by private interest. The Agricultural Research Council, which can be fully controlled by Parliament, in general is able to gain full co-operation from the University Agricultural Departments, Agricultural Research

Stations, and similar institutions. The Agricultural Research Council has hitherto lacked any firmly co-ordinated policy. It must in future have a plan, and ensure that it is understood by the various research organisations. If, in addition, the greater part of the extra finance is provided by the State through the Agricultural Research Council (raising its share of the money spent annually on agricultural research from £150,000 in a total of £200,000 a year, to £500,000 in £600,000,) and if this finance, used either to subsidise existing research stations or to provide new ones, is accompanied by an appropriate share in control, then the whole of British Agricultural research can be co-ordinated in a national plan with a minimum of bureaucratic interference.

SCIENCE AND HEALTH

Important advances can be recorded in the treatment and prevention of ill-health ; but there are serious problems requiring attention. The prevalence of the common cold, influenza, tuberculosis, cancer, rheumatism, the fevers of childhood and other common diseases, illustrates how much work has to be done.

The amount of research at present is trifling compared with the human and social need. The supply of medical services is patchy, often inefficient and inadequate. Treatment varies with the purse of the patient and the size of the practice or hospital. The health of the nation, which should be a prior charge on the attention of the State, has depended in the past largely on a system of private practice and appeals to charity, a state of affairs wasteful to talent and inimical to rapid progress.

The chemist, biologist, bacteriologist and workers in other fields of science have contributed very considerably to the science of medicine and have provided doctors with drugs of great value, such as the M & B series, penicillin and so on. Nevertheless, private control of pharmaceutical research hampers its development and places the main emphasis on the competitive sale of patent medicines. Hospital workers

and doctors are confronted with an endless stream of products. Some are undoubted improvements on already established drugs but others are mere refinements of the products of competitors. The public, reluctant to seek medical advice or to attend a hospital because of the cost, the time wasted, or the unpleasant atmosphere of charity, is exhorted to treat itself by patent medicine advertisements on hoardings and in the newspapers.

The new National Health Service will overcome many of these deficiencies. Medical aid can become more nearly a matter of scientific administration and there will be a better basis for an expansion in medical research. These results will follow from the co-ordination of the health services, the establishment of Health Centres providing the medical practitioner with a variety of equipment, specialist consultation and the benefits of team-work, and the more even distribution of services through the country. Central and regional co-ordination will assist the collection and analysis of clinical data on which the development of health policy and the direction of research throughout the field can be based. Organised reporting from Health Centres and Hospitals can provide much valuable statistical information for this purpose.

The desirable level of research cannot be attained in a short time because of the pressing need for medical personnel in practice and hospital work. It should, however, be possible to double the scale of pre-war research within the next ten years.

Lines of research that merit special attention are given in the Appendix.

Co-ordination

Besides pharmaceutical firms, hospitals and independent institutions, there are several government agencies which carry out medical research, as well as the Medical Research Council.

The Medical Research Council is rightly held in high esteem in the field of medical research. It is therefore in an

excellent position to draw all medical research into line in accordance with a plan based on national needs, as occurred to some extent during the war. The increased finances required for expansion should be administered largely through this body.

SCIENTIFIC ASSESSMENT OF CONSUMERS' NEEDS

Research is needed to determine the characteristics for standardised articles to satisfy the majority of users and also provide variations from the standard to cope with the needs of significant minorities. Legislation defining minimum quality standards for all products is necessary.

Techniques have been developed in wartime. Social surveys (the 'Gallup poll' method being the prototype) discover, by sampling, the views and wishes of people ; and in operational research, much experience has been gained in the problem of adapting equipment and machinery to the most convenient form from the user's point of view.

One or more institutes should be established for consumer research financed and controlled by the Government, although a great part of the work should be undertaken in the ordinary course of industrial research.

Eventually scientific assessment of requirements should become the basis for planning all research. In the more scientific socialist world it will take high priority among all applied branches of science.

A provisional target for beginning this type of research would be an expenditure of £500,000 a year at the end of ten years, with about 500 qualified workers and assistants in public consumer research institutes and industrial research establishments.

NATIONAL RESEARCH AND DEVELOPMENT COUNCIL

All aspects of research should fit into a comprehensive national plan and the work of research organisations should dovetail into this picture.

This requires the establishment of a body responsible to the Cabinet with controlling and co-ordinating powers. We shall describe this body as the National Research and Development Council.*

Powers and Functions

To work out a national plan for research and development.

To provide the Cabinet with information on scientific progress, and to translate Cabinet decisions on economic and social development into research policy.

To provide generalised decisions of policy to be worked out in detail by the D.S.I.R., the Medical Research Council and the Agricultural Research Council.

To assign priorities according to national needs. To allocate problems to appropriate organisations or industrial concerns.

To allocate finance and manpower to research bodies in accordance with work to be done.

Organisation

The N.R.D.C. must have a minimum of administrative machinery but possess a considerable fact-finding organisation. It should be directly responsible to the Lord President of the Council. It should be composed of representatives of the D.S.I.R., the M.R.C. and the A.R.C., other government departments which carry out scientific work, the Royal Society, the Universities, industrial managements, the T.U.C. and scientific workers.

A federation of all representative organisations of scientific workers would simplify their representation on the N.R.D.C., as well as providing other advantages.

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* As this memorandum goes to press, the Government has announced its decision to set up an Advisory Council on Scientific Policy to advise the Lord President of the Council in the exercise of his responsibility for the formulation and execution of Government Scientific Policy. This body is to work closely with the Defence Research Policy Committee and both are to be under the same chairman. While there has not been time to examine the details of the decision, it is to be welcomed in general as a positive move towards the proposals contained here under the heading "National Research and Development Council."

FUNDAMENTAL RESEARCH

In this Memorandum we are chiefly concerned with fundamental research as the *foundation* on which applied science is based. From this point of view fundamental research is to be regarded as a long-term investment which can yield dividends of enormous magnitude.

Financial allocations from the State to the Universities, where most of this work has been done in the past should be supplemented with sums which will enable the amount of research to be progressively increased, reaching double the pre-war level of expenditure in ten years. There has been no shortage of competent graduates in the past, but many have been driven into other fields by lack of money. To increase and maintain the flow of workers into fundamental research it will be necessary to extend to post-graduate years the principle of full maintenance grants for all showing the necessary ability. Shortage of accommodation makes this only partially possible to begin with, but it should become general practice within ten years.

Planning

The type of planning that we have advocated for applied research is not suitable for fundamental research, since results from the latter are not nearly so capable of forecast. Some of the broadest aspects of planning, however, do apply. For example :—

(i) The provision of funds represents the decision to devote a certain proportion of our manpower and other resources to fundamental research. At present, many University departments are compelled to rely, to a considerable extent, on grants coming in various forms from industrial firms. Though several industrial firms have given nominally unconditional grants, in general it is to be expected that grants will only be given by private firms when they can expect results which will serve their own interests. The freedom of fundamental research is, to that extent, restricted. Thus State provision of adequate funds is a step towards freedom of planning for fundamental research.

(ii) Financial planning can be more detailed. Some branches of research have been badly neglected in the past, e.g., microbiology and physical chemistry.

(iii) Planning should be in the hands of a Fundamental Research Council representative of the Universities, the Royal Society and other appropriate bodies, and consisting largely of active fundamental research workers of responsible status. It would consider such problems as we have mentioned above, make recommendations on financial matters to the University Grants Committee (which controls State grants to the Universities), seek to achieve by voluntary co-operation of the various Universities and similar bodies a balanced policy for fundamental research, and maintain close contact with the National Research and Development Council. Within each University a similar function should be exercised by the University Council, the programme for research formulated at this level being submitted for wider discussion and criticism to a larger body consisting of everyone above the status of undergraduate. In this way, democracy in the Universities can be broadened.

(iv) Liaison between fundamental and applied research would assist in the selection of problems in the context of current technical developments. This could be achieved by the National Research & Development Council and the Fundamental Research Council, by (a) more frequent exchange of personnel ; (b) University vacation courses for industrial and Government research workers dealing with advanced fundamental work.

Atomic Energy

Research in nuclear physics and the utilisation of atomic energy requires special treatment. The social consequences of the application of atomic energy for industrial purposes are so fundamental that this is a case for strong political control from the beginning. At the same time the consequences of misuse, and of military application, are so devastating that social control must be stringent.

The problems of atomic energy are international and beyond

solution by one country or within national boundaries. They are the affair of the United Nations Organisation. The plan submitted to the Security Council by the United Nations Atomic Energy Commission, and the proposals suggested by the Soviet Government, require careful examination. The U.S. plan, as adopted by the U.N. Commission, proposes, briefly, continued monopoly and manufacture of the atomic bomb by the U.S.A. until such time as the U.S. Government is satisfied that other nations agree with its proposals regarding world organisation. Actual manufacture of atomic bombs, it should be noted, is in the hands of American monopoly concerns. The Soviet proposals take the position that the atom bomb and other weapons of mass destruction should be banned forthwith, and that no further atom bomb manufacture or research should take place.

British developments must be considered against this international background. The efforts of the research institute at Didcot will not be so socially useful if they are concentrated on bomb production at the expense of research for industrial power.

The Government's legislation for atomic energy contains necessary provision for State control over material and products, but the obligations of secrecy laid down cover workers in an ill-defined field of activity associated with nuclear physics. The liberty of scientific workers can thus become severely restricted and progress of science retarded by bans on the publication of results in a wide field of research. Secrecy in atomic research defeats the ostensible object for which it is demanded, namely the preservation of peace. The history of the secret activities of some countries on the development of new weapons shows that it only results in the creation of mutual suspicion among nations, competition in weapon production, and deterioration in international relations.

Application of atomic energy in industry, and of new production processes, including all entirely new technology, which will probably arise from discoveries in nuclear physics, will involve tremendous social and economic changes, vast

reconstruction and wide scrapping of old factories, industries and institutions. Such problems cannot, indeed, be solved completely and permanently under capitalism. They are so fundamental that only Socialism can provide the degree of social control required to harness atomic energy usefully.

DEMOCRATIC PLANNING

The fear is often expressed that the planning of scientific research for human needs will inevitably bring with it bureaucratic regimentation and a stifling of free initiative. This view fails to take note of the fact that, in the past, our scientific effort has **not** been unplanned. It has lacked a national plan based on the needs of the people. Nevertheless, there have been many large organisations within which a planned research programme has been carried out. The most important have been certain government departments and the larger industrial concerns. Too frequently their planning has been carried out on bureaucratic lines, which scientists rightly consider inimical to progress. Reactionary propaganda makes much of the bureaucracy in the government departments, although in fact it is much worse in monopoly industrial concerns.

When research is directed to the interest of the people, scientists in general play their part willingly. Planning, in these conditions, becomes voluntary co-ordination, to ensure the most efficient use of manpower and to achieve the best results. It can and must become part of a democratic structure, in which suggestions from below play as important a part as instructions from above. Every facility must be given for scientific workers at all levels to put forward suggestions and have them fully discussed. Industrial workers and consumers, as the people affected by research, must also play their part in taking decisions.

Here are some suggestions on methods:—

(1) The Trade Unions should press for representation on the governing bodies of the Research Associations which con-

cern their own industries, and should exert their full power in determining policy. The National Union of Mineworkers has given an example by securing two representatives on the Governing Council of the British Coal Utilisation Research Association. Trade unionists must become conversant with technical problems so as to play their part fully in the control and management of industry.

(2) Joint Production Committees should have the same rights to discuss the work of factory laboratories as with production in general.

(3) Scientific workers should be represented by right on the workers' side of the J.P.C.s.

(4) In every scientific institution the governing body which controls policy should contain elected representatives of the rank and file scientific workers. Similar representation is necessary in government departments.

(5) Parliament should take a more direct interest in the work of government scientific departments and other scientific organisations which are wholly or partly controlled by the State. Parliament should, where necessary, appoint M.P.s to share in forming the policy of these bodies.

(6) All scientifically valuable results should be published. Public relations work of government research establishments should be strengthened, especially amongst the trade unions.

FINANCE

The amount of money required for the proposed research programme is not sufficient to affect seriously other national needs. Some rough indications are given below. Future needs can only be assessed accurately when a body such as the National Research and Development Council comes into existence. [Finance for research on defence (estimated at £2 millions a year about 1936) and for social and psychological science is omitted.]

ESTIMATED ANNUAL EXPENDITURE (IN £ MILLIONS)

	Pre-war	Post-war aim for 10 years after end of war	Government expenditure as part of this
Industrial Research ...	3.0	11.0	5.5
Agricultural Advisory Services	0.6	6.0	6.0
Agricultural Research ...	0.2	0.6	0.5
Medical Research (including Medical Research Council, Hospital and Pharmaceutical Research)	2.0	4.0	2.0
Consumer Research ...	negligible	0.5	0.4
Fundamental Research ...	1.0	2.5	1.7
	6.8	24.6	16.1

TRAINING THE SCIENTIST

Our proposals require the number of research workers to be rapidly increased. The number of scientists trained annually must be increased by five or eight times the pre-war figure, according to the rate at which educational expansion takes place. The annual number of new scientists trained for management, production, control testing, and so on, and for the Agricultural Advisory Services will also have to increase at least as fast, if scientific efficiency is to permeate the whole of industry. The problem is only slightly eased by the increase in the number of scientific workers during the war; for many of these require further training, while others have been temporarily withdrawn from teaching and other professions, to which they must return.

Two methods must be used to ease manpower difficulties. First, the efficiency of a research worker in many lines of work can be greatly increased by providing him with more adequate technical assistance. Secondly, many technical assistants who have acquired scientific knowledge and

experience could rapidly be trained to become research workers by the provision of specially adapted and shortened University courses.

However, there will remain the problem of training from scratch several times as many scientists as at present. The burden will fall on the Universities and Technical Colleges. Only about one-third of the graduates of Universities are scientists, and of these a great many are required for teaching and other purposes. There will be a need for a greater output of all types of qualified workers. The educational reforms will require many more teachers, and the National Health Service many more doctors. It appears likely, however, that the demand for graduates in other fields will increase less markedly than in science. We make the very rough and provisional estimate that the total output from the Universities and Technical Colleges needs to be increased to about four times its pre-war level in about ten years. Within this expansion very special emphasis should be laid on the training of scientific workers.

The scientific manpower required by various industries could probably be decided by the newly-constituted Regional Boards for Industry, and for particular industries by the tripartite working parties which have been set up (for example, in the pottery, cotton and other industries). The Central Register, formed in wartime for the purpose of using scientists to the best national advantage, should be maintained and should attempt to satisfy the demands of the various industries which have an urgent need for scientists. The supply of scientists to industrial concerns must be on the basis of national needs: coal, iron and steel and cotton, must have precedence over the luxury trades. To ensure this, a licensing system should be instituted, under which no firm is supplied with a licence to employ scientists unless the nature of its work justifies it.

The ultimate determination of what happens to scientific manpower should rest with the National Research and Development Council, but close liaison must be maintained between it and the Regional Boards for Industry.

CONDITIONS OF WORK FOR SCIENTISTS

To provide the required increase in the number of scientists conditions under which scientists work must be improved.

Salaries are usually a matter for individual arrangement, as scales and grading are abhorrent to most employers. Thus improvements are at the discretion of managements. Hours are long, holidays short, and arrangements for such matters as payment for absence through sickness, niggardly in the extreme. The employer has the sole right over the work done, and often withholds from the scientist the right of publication. The scientific worker is expected to fit into a scheme of things about which he is not consulted and which impose upon him restrictions in the full use of his abilities.

Scales of salaries are necessary, based upon realistic grading schemes such as those drawn up jointly by the British Association of Chemists and the Association of Scientific Workers for chemists, and the salary scales, hours of work, holidays and payment for sickness for engineers recommended by the A.Sc.W. Such agreements should be incorporated in collective agreements between employers and the appropriate trade union, and they should make provision for educational facilities: for example, time off from work without loss of pay for refresher courses or special studies. Certain rights of the scientist in industry should be established, such as the right to publish, and rewards for special achievement. The way in which these things can be secured is through trade union action, and the trade unions catering for scientists must be strengthened by a much larger recruitment.

The White Paper on a State Scientific Service (Cmd. 6679) embodies proposals, which are now largely implemented, designed to remedy the failure of past governments to retain the services of the best scientists. Bigger changes are needed, however. The scientist must have equal status with the administrator.

The improvement of conditions of scientists is a matter of grave concern also in the research associations, where conditions are usually rather below those in the Civil Service.

The position of technical assistants needs special attention. Apart from giving technicians every opportunity to become fully qualified, the profession of Laboratory Technician should be regarded as a career in itself. This demands not only good salary scales, and grading schemes to ensure prospects and promotion, but also adequate educational facilities, including courses at the Universities and Technical Colleges, with diplomas in laboratory arts and techniques. The latter should offer inducements to specialisation in a wide range of subjects. This problem has already received the attention of a number of organisations, and steps are being taken to produce a scheme sponsored by representatives of the interests concerned (employer as well as employee) to place the Laboratory Technicians on a proper professional basis. The raising of the professional level of technical assistants in the ways suggested will have a greatly beneficial effect on the quality and quantity of scientific work.

THE INTERNAL EFFICIENCY OF SCIENCE

There are many ways in which the internal efficiency of scientific activity should be improved. The methods of publishing scientific results, for example, are chaotic. There is a profusion of overlapping publications, only slightly ameliorated by the appearance of a few abstracting journals. One of the first tasks of the National Research and Development Council should be to introduce the necessary reforms.

This will have to be backed on an international scale. The United Nations Educational Scientific and Cultural Organisation should investigate the question and arrange international agreements.

Facilities for specialised testing or for the supply of high-quality chemicals should be made available much more widely. At present much time is wasted by scientists improvising for themselves.

Centralised facilities for computation are also required. The recent decision to set up a mathematics division of the National Physical Laboratory is a welcome innovation. The application of statistical methods to the analysis of experi-

mental results can be not only a great aid in interpretation, but can also save a good deal of labour in experiments. Thus, where the services of a mathematician are not available a department should be available for this work, particularly where large-scale fieldwork is going on (such as may be undertaken by a Research Association) and where it is particularly important to cut down the number of experiments to a minimum.

A highly efficient scientific instrument industry is vital. There must also be facilities for the construction and use of very specialised apparatus, to avoid waste of money on contracts at high prices with engineering firms.

Ultimately the use to which science is put depends on the action which the people as a whole take to direct it to proper ends and to understand its purposes and methods. Every organisation can take part in this—the Labour and Communist Parties, the Trade Unions, the Co-operative movement, and many others. In doing so, they will not only be fighting for an immediate improvement in the standard of life, but they will also be strengthening the general struggle for Socialism, under which science will at last fully become applied to the service of the people.

This idea is becoming more widely recognised in the trade union movement. Several organisations, such as the Miners' and Engineers', have taken an increasing interest in the technical development of their industries, and in possible changes arising out of new technique. The T.U.C. has revived the Scientific Advisory Committee. These trends need to be encouraged, and there can be no doubt that scientific workers generally would welcome the opportunity of assisting trade unions to press for greater use of science in their industries.

At the same time, the scientific worker can learn much from other workers. He can obtain invaluable knowledge from the workers' first-hand experience of trade union organisation as a means of elevating the status of working people and obtaining better conditions of work and pay. The recent development of trade unionism amongst scientific

workers, particularly marked in the case of the Association of Scientific Workers, shows that these ideas are gaining ground. The Labour movement can welcome this development, for it is part of the great process of ending barriers between "workers by hand and workers by brain."

Trade unionism, however, is not enough. Scientific workers, like others, need to participate in the political struggle to ensure that their work is socially useful and progressive and that science is used for mankind's benefit instead of his exploitation. The Communist Party, which numbers some outstanding scientific workers in its membership, is the type of organisation which progressive men and women in every sphere of science would find corresponds with their outlook on work and life. The Communist Party bases all its policy, teaching and activity on the scientific theory and practice developed by Stalin, Lenin and other workers from the original works of Marx. This science is concerned with the study of the social history of mankind; of the progress of humanity from primitive Communism through slavery, feudalism and capitalism, to Socialism; and of the means by which the working people living under capitalism can be assisted to achieve power over the capitalist class and to establish Socialism. In Socialist society scientific method and principle will permeate every department of life and make possible a vast transformation in the status, liberty and welfare of the individual human being.

Striving for this goal, the Communist Party currently sets itself the task of encouraging all working people by hand and brain to ally themselves together for the great political and industrial effort required to restore Britain to its position as a world leader in industry, science and the arts. In this aim, as in the aim of establishing Socialism in Britain, of which it is a part, the Communist Party calls on the aid of scientific workers and invites them to participate as members of its organisation.

APPENDIX

Some Headings for Research

[The following list is not intended to be exhaustive; it is given to indicate the many-sided character of the type of research programme urgently necessary for Britain to-day.]

Industrial

COAL MINING: Improved haulage systems; installation of coal-cutting machinery and improved grading and washing plant; alternative methods of coal-getting, preferably minimising underground operations, and including underground gasification; improved conditions of work; underground lighting standards; shot-firing methods; ventilation standards; nutritional standards; the cure and elimination of causes of lung and eye diseases.

COAL DISTRIBUTION COSTS: Standardisation of large-capacity trucks; materials for truck construction; methods of packing and distribution.

COAL UTILISATION: Raw materials for the chemical, plastic and synthetic fuel industry; reduction in energy and chemical raw material wastage involved by present methods of burning coal; coal and plastics; coal and synthetic fuel; possible development of atomic energy as an alternative to coal emphasises the need for research into coal as a source of material for plastics and chemicals.

FUEL AND POWER: A unified national policy is needed for all fuel and power resources, including coal, waterpower, alcohol, oil, etc; use of waste heat from power stations; lighting technique; railway electrification; design of furnaces, carbonising and steam raising plant; use of peat, of which there are great quantities; use of methane from mines, sewage and coke-oven gas.

CHEMICAL AND ALLIED INDUSTRIES: Utilisation of sewage, earths and clays, by-products of iron, steel and carbonisation industries as sources of chemicals; improved production of phosphates, sulphuric acid, aluminium and other light metals; properties of building materials and investigation into use of new materials, including plastics.

METALS: A Research Association was set up recently to deal with problems of this industry, which include—redesign of blast

and smelting furnaces; utilisation of low-grade iron ore (plentiful supplies are available in Britain); improvement in the quality of metallurgical coke; re-equipment of the iron and steel industry; improved production of the light metals and their alloys, including the use of hydro-electric power.

TRANSPORT AND COMMUNICATIONS: Railway electrification; design and construction of roads; safety devices for transport by air, land and sea, including radar methods of railway signalling.

BUILDING: New building materials; building technique; heating, ventilation, lighting; sound and heat insulation; layout in houses.

TEXTILES: Modernisation of plant and factories; strength, wearing properties and texture of textiles; application of new scouring methods to wool and cotton; the use of new synthetic fibres, such as nylons; the application of plastics to textiles, e.g., the use of silicon resins for waterproofing and strengthening fibres.

ENGINEERING AND MANUFACTURE: Materials, design and production methods; development of mass-production methods involving highly automatic machines for all unskilled work; application of electronic technique to routine operations, testing, etc.

WORKERS IN INDUSTRY AND TRANSPORT: The design of plant with reference to the health, comfort and efficiency of the operator; problems of industrial hazard, requiring co-operation between plant designers, psychologists, physiologists and doctors; the physiological properties of new chemicals in relation to their effect on the workers; health services in industry and transport.

SOCIAL PLANNING IN RELATION TO INDUSTRY.

Agricultural

PLANT BREEDING: An extension of the work now being done at several research stations to improve varieties of all crops.

PLANT HEALTH: Investigation of weed control and pests.

ANIMAL HEALTH: With special reference to tuberculosis, mastitis and sterility to cattle, and the whole range of sheep diseases.

ANIMAL BREEDING: To improve the quality of cattle (especially milk production and meat quality and quantity); artificial insemination combined with breeding and genetical work to improve stocks and help to break up pedigree monopolies.

MECHANISATION: Design of improved instruments and machinery; design of implements for specifically British conditions; main emphasis on the economic use of manpower. This can be based on an extension of the work being carried out at Askham Bryant.

CHEMICAL AND BIOLOGICAL RESEARCH: Into soil and fertility problems.

PRESERVING, PROCESSING AND TRANSPORTING FOOD AND AGRICULTURAL PRODUCTS.

ECONOMIC RESEARCH INTO MARKETING SYSTEMS.

Medical

PREVENTIVE AND SOCIAL MEDICINE: Investigation into living and working conditions, housing requirements, factory conditions, sanitation, etc., is already being done on a limited scale. The need here is for large-scale investigations. The organisation of special institutions to investigate these problems, under the general directions of the Medical Research Council, should be considered.

INDUSTRIAL MEDICINE: Besides the improvement and extension of the Factories Regulations (1937) and the provision of an industrial health service, there is need for much more research into industrial diseases such as silicosis, dermatitis, and various forms of chemical poisoning.

COMMON DISEASES: An organised attack, linking the whole range of methods from clinical to fundamental biological research, is required for the reduction in incidence and possible elimination of: the common cold, influenza, fevers of childhood, tuberculosis, cancer, rheumatism. Together with the application of the results of research into social conditions, housing, etc., enormous gains could be confidently anticipated from work of this nature.

PHARMACEUTICAL RESEARCH: This requires to be freed from the control of the powerful vested interests and co-ordinated with the required developments in medical science.

CLINICAL RESEARCH : Larger number of highly qualified medical workers are required for full-time employment in the hospitals. Such posts must be sufficiently well paid to attract the best talent. The National Health Service must make the necessary provision for this in the hospitals.

Colonial

Scientific and technical development is essential in the Colonies. Raised living standards for colonial people will mean better living standards in other parts of the world, besides bringing the largely untapped talents of millions into the service of mankind. Lines of research include the following :

MINERAL AND OTHER RESOURCES : Geological and chemical surveys; use and development of plant and other natural products.

INDUSTRIAL : Especially iron, steel, metallurgical and heavy chemical industries.

POWER : Coal, iron, electricity, water power.

TRANSPORT : Road, rail, water and air.

AGRICULTURE : Soil erosion and composition ; crop improvement; improvement in farming methods by use of machinery and fertilizers ; irrigation ; type of crops ; plant breeding ; insect, bacterial and fungal infection.

SOCIAL CONDITIONS : Houses and housing standards ; sanitation ; treatment and control of disease ; nutrition.

EDUCATION AND TRAINING OF SCIENTIFIC WORKERS : Britain must provide scientific workers for the initial stages of the work needed in the colonies ; parallel with this must go the planned expansion of training facilities to produce the number of personnel required. Technical and scientific jobs must carry adequate salaries and status.